Learning local modules in dynamic networks

Paul M.J. Van den Hof and Karthik R. Ramaswamy

Department of Electrical Engineering - Control systems group, Eindhoven University of Technology

Link:https://youtu.be/Icugq4rF050

Single module identification

Single module identification deals with the identification of one particular component –or module– of the network.

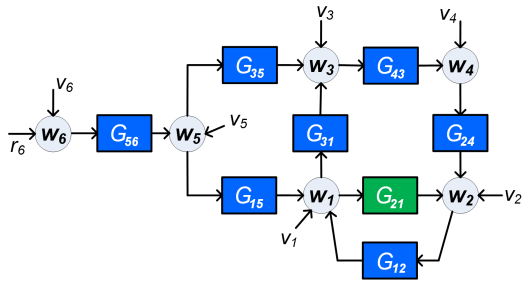


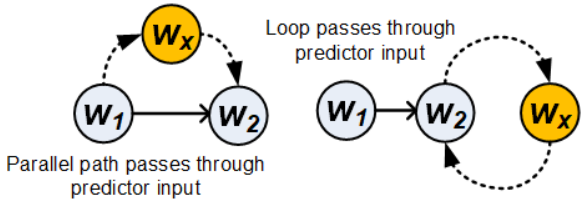
Figure 1: Example network with the green module G_{21} being the target module for identification.

Direct method [1]

For consistent identification of target module G_{ji}

- Node signals as predictor inputs w_D and predicted output w_Y with $i \in \mathbf{D}$, $j \in \mathbf{Y}$;
- $\varepsilon(t,\theta) = \bar{H}(q,\theta)^{-1}[w_Y(t) - \bar{G}(q,\theta)w_D(t) - \bar{R}r_P(t)]$;
- Includes a noise model, indirect method not necessarily need a noise model.

Parallel path and loop condition:



Handling confounding variables:

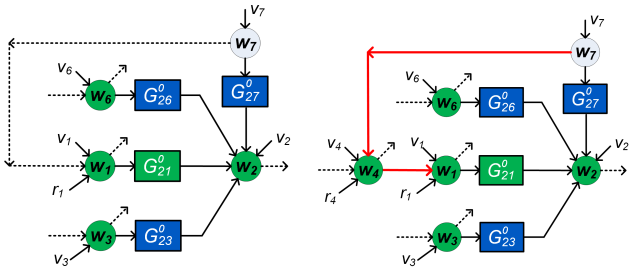
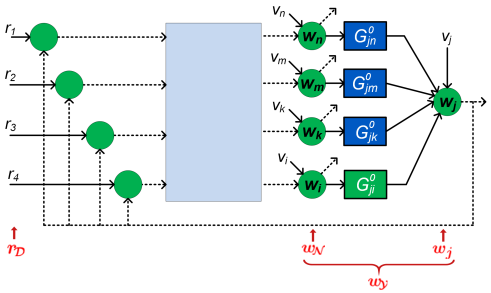


Figure 2: Disturbances that affect both inputs and output are handled by adding predictor inputs or predicted outputs.

Indirect method [2]

For consitent identification of G_{ji}

- External excitation signals as predictor inputs for an open loop MIMO identification problem : $\varepsilon(t,\theta) = w_Y(t) - \bar{T}(q,\theta)r_D(t)$;
- *post-processing* : $\hat{G}_{jN} = \hat{T}_{jr_D}\hat{T}^{\dagger}_{Nr_D}$;



Data informativity: Vertex-disjoint paths

Method	From	To
Direct method	r and v-signals	w_D
Indirect method	r signals	w_N

Generalized method

For consistent identification of target module G_{ji}

- Combine elements of direct and indirect methods;
- Both nodes signals and external excitations are used as predictor inputs. Post processing allowed. More flexibility in selecting node signals and relaxed excitation conditions;
- $\varepsilon(t,\theta) = \bar{H}(\theta)^{-1}[w_Y(t) - \bar{G}(\theta)w_{D_w}(t) - \bar{T}(\theta)r_{D_r}(t)]$.

Algorithmic aspect - kernel based methods [3]

Introduced to handle the computational complexity in large-scale network identification.

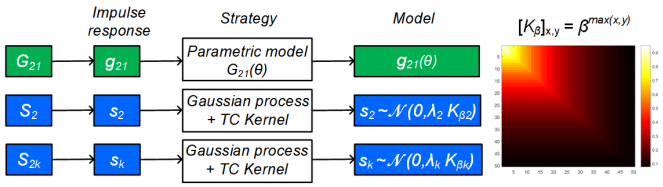


Figure 3: Only the target module is parameterized. Rest of the modules have only 2 hyperparameters to describe their dynamics.

References

[1] K. R. Ramaswamy and P. M. J. Van den Hof, "A local direct method for module identification in dynamic networks with correlated noise," *IEEE Trans. Automatic Control*, vol. 66, no. 11, 2021, to appear.

[2] M. Gevers, A. Bazanella, and G. Vian da Silva, "A practical method for the consistent identification of a module in a dynamical network," *IFAC-PapersOnLine*, vol. 51-15, pp. 862–867, 2018, proc. 18th IFAC Symp. System Identif. (SYSID2018).

[3] K. R. Ramaswamy, G. Bottegal, and P. M. J. Van den Hof, "Learning linear models in a dynamic network using regularized kernel-based methods," *Automatica*, vol. 129, no. 7, 2021.